



TITLE:

The Chemistry on Diterpenoids in 1978. Part-II

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CITATION:

Fujita, Eiichi ...[et al]. The Chemistry on Diterpenoids in 1978. Part-II. Bulletin of the Institute for Chemical Research, Kyoto University 1980, 57(5-6): 385-410

ISSUE DATE:

1980-01-31

URL:

<http://hdl.handle.net/2433/76846>

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Review

The Chemistry on Diterpenoids in 1978. Part-II¹⁾

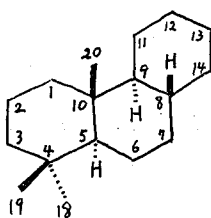
Eiichi FUJITA*, Kaoru FUJI, Yoshimitsu NAGAO, and Manabu NODE

Received September 5, 1979

I. INTRODUCTION

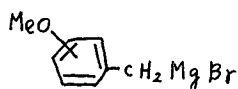
This is one of a series of our annual reviews on diterpenoids chemistry. The classification of the compounds is the same as that adopted in our reviews since 1969. This review covers the literatures published between July and December 1978 and also omissions in Part-I.

II. PODOCARPANE DERIVATIVES



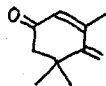
Podocarpane

Copper-catalyzed 1,6-addition of benzyl Grignard reagents **1a** and **1b** to a dienone **2** gave rise to **3a** and **3b**. Acid-catalyzed cyclization of the products gave 1:1 mixture of A/B *trans*- and *cis*-2-oxopodocarpa-8,11,13-trienes **4a** and **4b** respectively, while cyclization of the allylic alcohol **5** gave the A/B *cis*-isomer **6** in good yield.²⁾

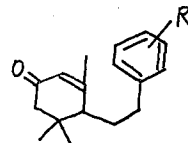


(1a) *para*-OMe

(1b) *meta*-OMe



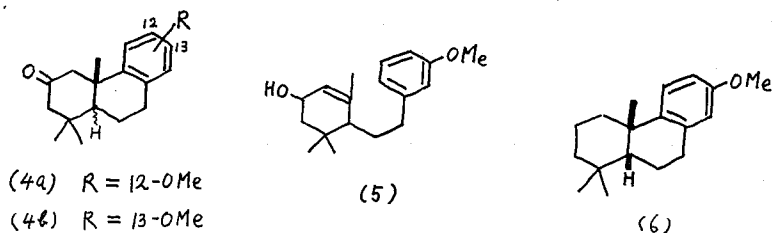
(2)



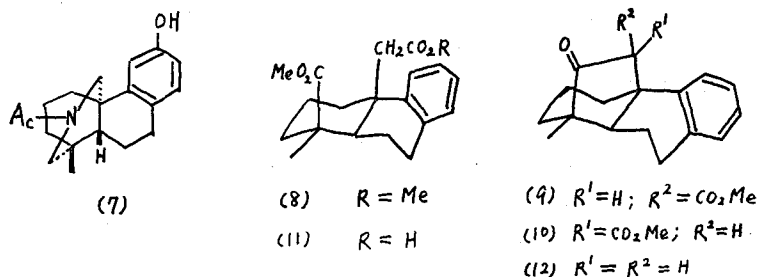
(3a) R = *p*-OMe

(3b) R = *m*-OMe

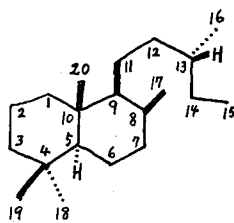
* 藤田栄一, 富士 薫, 長尾善光, 野出 学: Laboratory of Physiological Activity, Institute for Chemical Research, Kyoto University, Uji, Kyoto-Fu 611.



A stereocontrolled total synthesis of (\pm)-19 α ,20 α -(acetylimino)-12-hydroxy-5 β ,10 α -podocarpa-8,11,13-triene (7), a degradation product of atisine, was reported.³⁾ Dieckmann cyclization of 8 in refluxing 1% aqueous methanolic KOH gave 9 and 10 in 85% yield and 11 in 13% yield.⁴⁾ The conformation of 12 in crystalline state was determined by X-ray analysis. Ring A in 12 is in a distorted chair conformation, whereas ring B is in a distorted boat conformation.⁵⁾



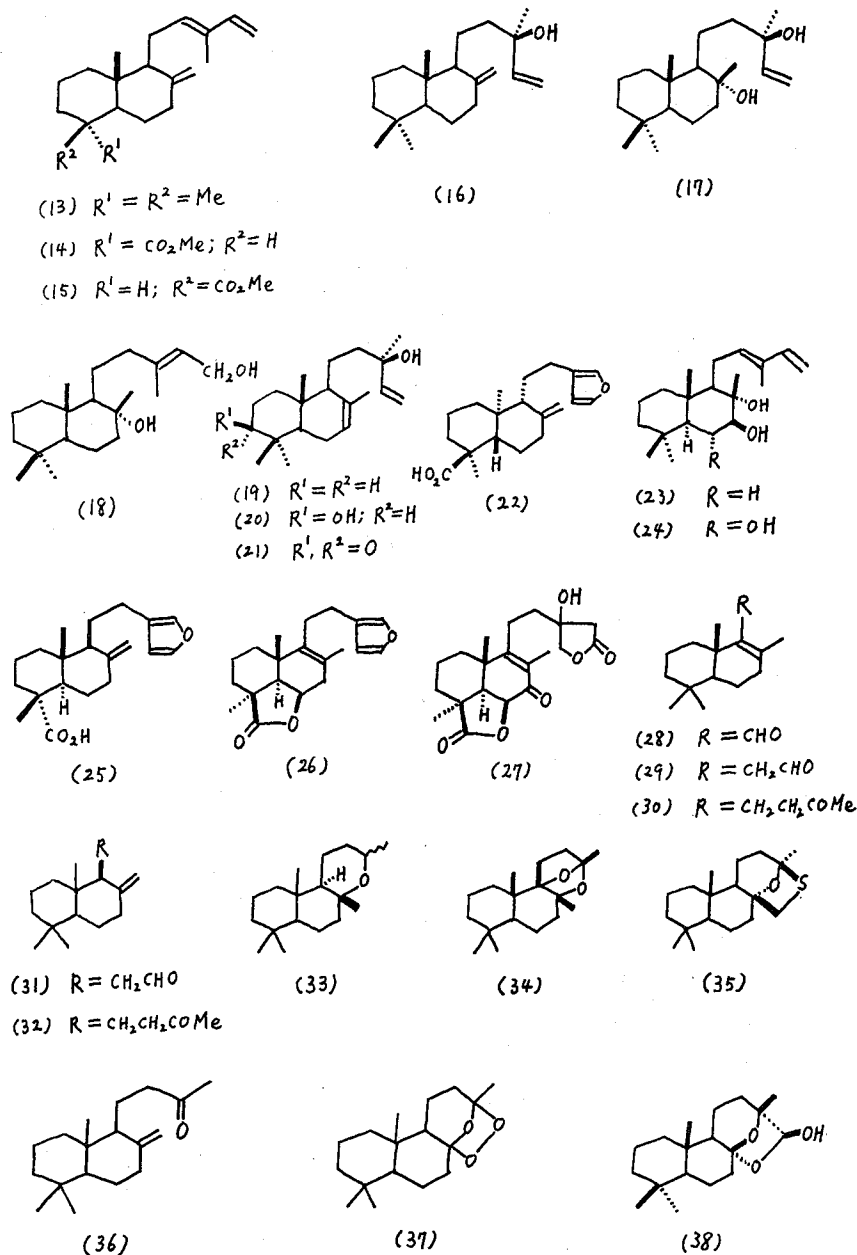
III. LABDANE DERIVATIVES



Labdane

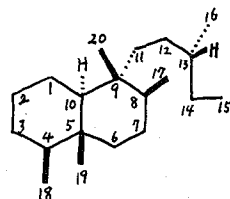
Labdanoid diterpenes 13–18 from *Helichrysum confertum*, 19–21 from *H. albirosulatum*, and 13, 16 and 17 from *Denekia capensis* were isolated.⁶⁾ Root of *Critonia daleoides* was found to contain a furanoditerpene 22.⁷⁾ Labdane derivatives 23 and 24 were isolated from *Nidorella auriculata* ssp. *polyccephala*.⁸⁾

(+)-Polyalthic acid (25) was isolated from *Sequoia semperivirens*.⁹⁾ A new diterpene, 13-hydroxyballonigrinolide (27) was isolated from *Ballota lanata*, together with a known diterpene, ballonigrin (26).¹⁰⁾ Investigation by gas liquid chromatography of a small subfraction of Oriental tobacco condensate (*Nicotiana tabacum* L.) led to the identification of norlabdane derivatives 28–34.¹¹⁾ 13,17-Epithio-8,13-epoxy-14,15-dinorlabdane (35) was synthesized.¹²⁾



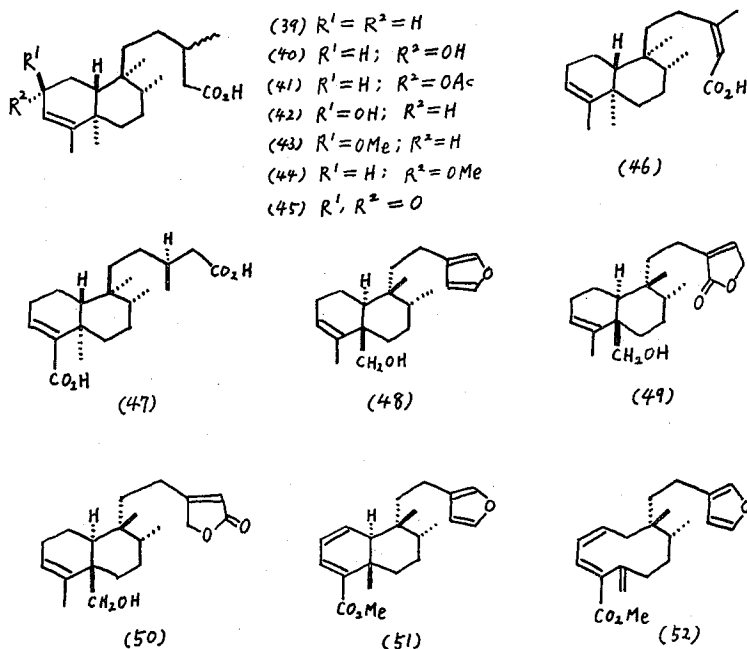
Hydroxymethylation of **36** led to the synthesis of a new series of intramolecular acetals related to known perfumery compounds.¹³⁾ A stable ozonide **37** was isolated from the ozonolysis of manool. Another major ozonolysis product was 8 β ,13:8,14-diepoxy-15,17-dinorlabdan-14 β -ol (**38**).¹⁴⁾

IV. CLERODANE DERIVATIVES

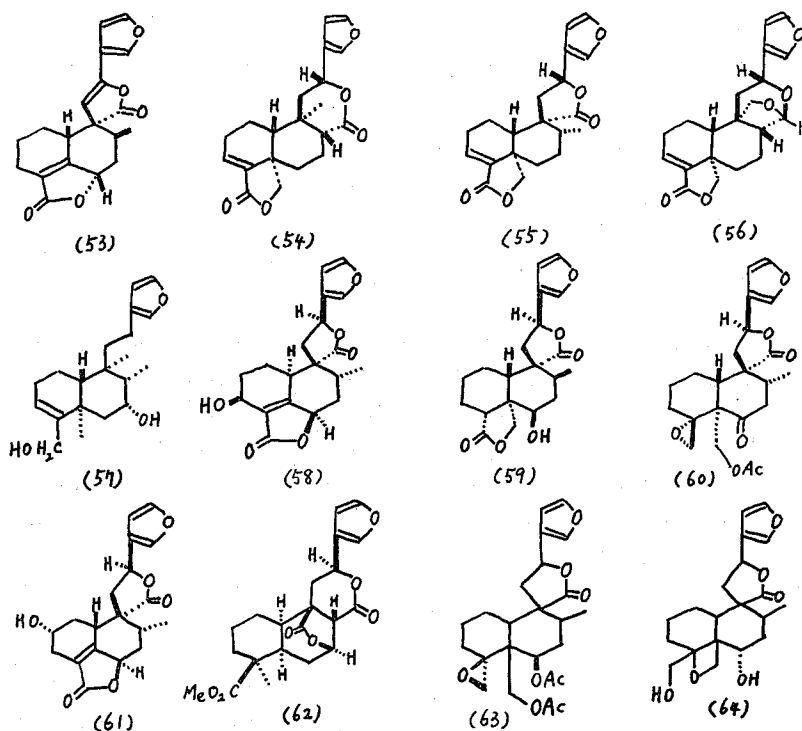


Clerodane

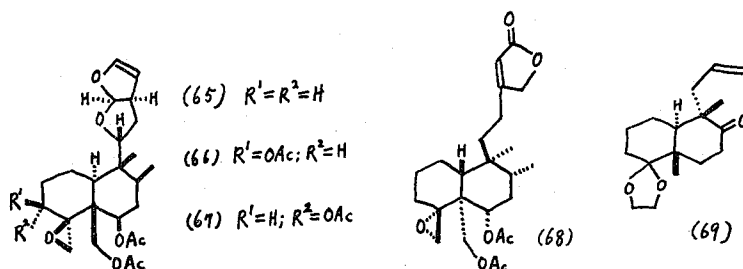
Populifolic acid (39) and its derivatives 40–45 were isolated from *Cistus populifolius* as their methyl esters.¹⁵⁾ *cis*-Kolavenic acid (46) and its dihydro-derivative were isolated from *Fleischmannia sinclairii*.⁷⁾ Since stereochemistry at C-13 of populifolic acid (39) and dihydrokolavenic acid has not been determined and direct comparison of these compounds has not been done, identity of these diterpenes remains uncertain. The structure of a new diterpene isolated from *Haplopappus ciliatus* was elucidated to be 47 by X-ray diffraction techniques.¹⁶⁾



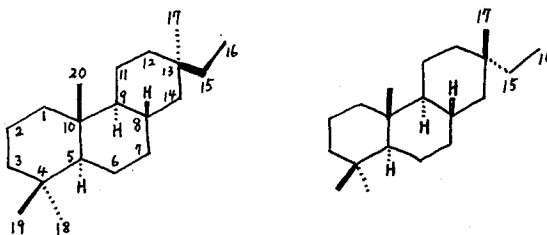
Three new diterpenes 48–50 from *Nidorella agria* and two new diterpenes 51 and 52 from *N. resedifolia* were isolated.⁸⁾ Isocrotocaudin (53) was isolated from *Croton caudatus*.¹⁷⁾ The hexane extract of the Colombian medicinal plant *Baccharis tricuneata* yielded four new *ent*-clerodanes, bacchotricuneatins A–D (54–57).¹⁸⁾ Teucrins HI¹⁹⁾–H4 (58–61) were isolated from *Teucrium hyrcanicum* and their structures were determined²⁰⁾. *Croton diasii* was found to contain a new diterpene diasin (62).²¹⁾ Montanin C (63)²²⁾ and D (64)²³⁾ were isolated from *Teucrium montanum*.



The absolute stereochemistries of clerodin, caryoptin, and 3-epicaryoptin were corrected to the enantiomeric forms of the previously reported formulas **65**, **66**, and **67**, respectively, from the results of some chiroptical data.²⁴⁾ Diels-Alder approach to the synthesis of the antifeedant, ajugarin I (**68**) was reported.²⁵⁾ A potential intermediate **69** in the synthesis of friedolabdanes was prepared and its reactions with peracid, ozone, and diborane were studied.²⁶⁾

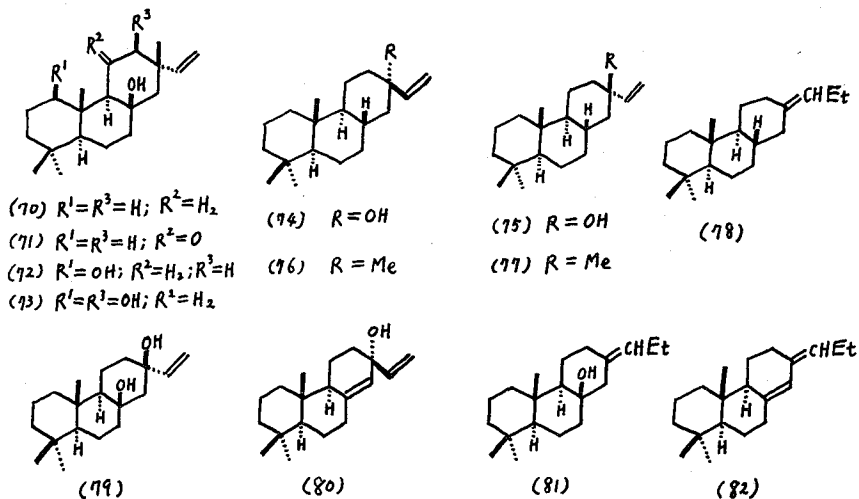


V. PIMARANE AND ISOPIMARANE DERIVATIVES

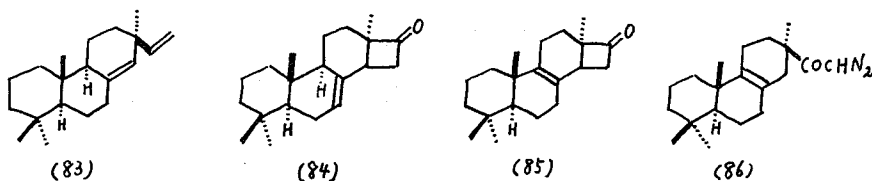


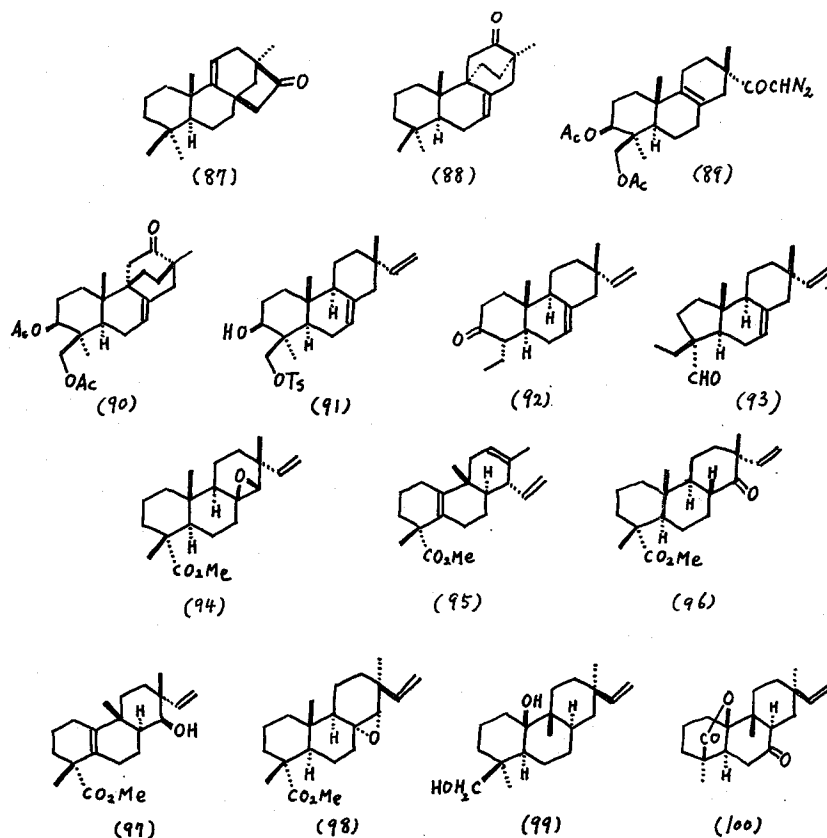
Pimarane and Isopimarane

The sandaracopimarane-15-enes **70–73** were isolated from *Premna latifolia*.²⁷⁾ In the presence of bis(triphenylphosphine)nickel dichloride both vinylcarbinols **74** and **75** reacted with methylmagnesium bromide affording a *ca.* 74:4:24 mixture of hydrocarbons **76**, **77**, and **78** (two isomers), respectively. The first olefin **76** was transformed into hibaene in five steps. In contrast to **74** and **75**, on reaction with methylmagnesium bromide vinylcarbinols **79** and **80** exclusively afforded the terminally methylated olefins **81** and **82**, respectively.²⁸⁾



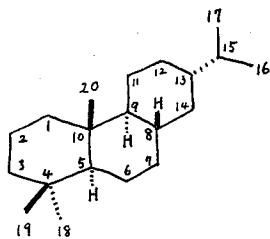
Pimaradiene **83** was converted into D-norsteroids **84** and **85**.²⁹⁾ Intramolecular C-alkylation of a diazoketone **86** derived from pimaradiene **83** gave a mixture (60:40) of the two isomeric ketones **87** and **88**. On the other hand, diazoketone **89** gave **90** as the sole product.³⁰⁾ Solvolysis of virescenol B 19-tosylate (**91**) in DMSO gave **92** and **93**.³¹⁾





Boron trifluoride etherate catalyzed rearrangement of methyl 8,14 β -epoxysandara-copimarate (**94**) afforded a mixture of **95** (33%), **96** (9%), and **97** (40%).³²⁾ The cleavage of methyl pimarate 8,14 α -epoxide (**98**) with a variety of acidic reagents was studied and a suggestion that the pimaranes are not the biogenetic precursors of the tetracyclic diterpenes was provided.³³⁾ Compound **99** was comparatively efficiently incorporated into rosenonolactone (**100**).³⁴⁾

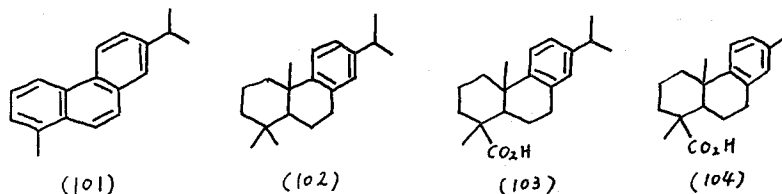
VI. ABIETANE DERIVATIVES



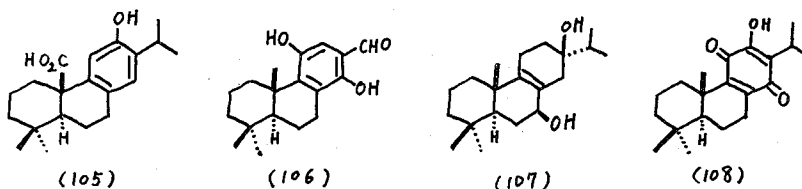
Abietane

In organic matter in the sediments in Hiro Bay near outlet of pulp mill waste

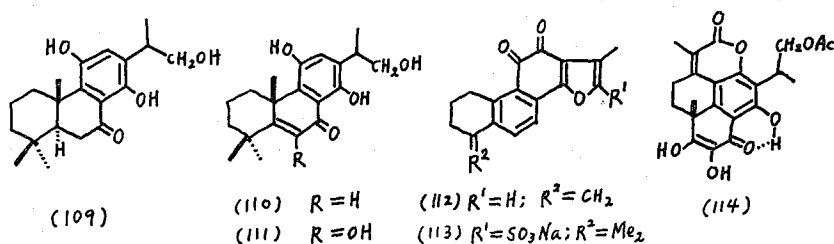
water, retene (**101**), dehydroabietane (**102**), and dehydroabiatic acid (**103**) were identified by GC-MS.³⁵⁾ Dehydroabiatic acid (**103**) and its homolog **104** were found in the lignite extract.³⁶⁾



Two new compounds, pisiferic acid (**105**)³⁷⁾ and premnolal (**106**)³⁸⁾ were isolated from *Chamaecyparis pisifera* and *Premna latifolia*, respectively. The isolation of a new diterpenoid ibozol (**107**) together with the known 7 α -hydroxyroyleanone (**108**) from *Iboza riparia* was reported.³⁹⁾

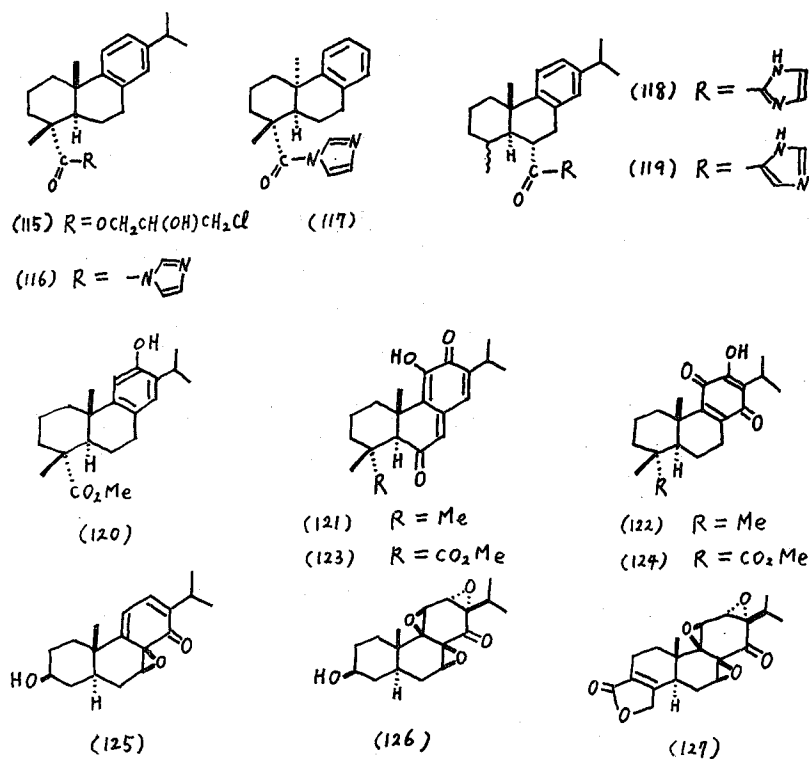


Three new diterpenoids, **109** (nellionol), **110**, and **111**, were isolated from *Premna latifolia*.⁴⁰⁾ Methylene-tanshinquinone (**112**) was isolated from *Salvia miltiorrhiza* along with the known tanshinones. Its sulfonate derivative **113**, which was useful in treatment of angina pectoris, was prepared.⁴¹⁾ From *Plectranthus edulis*, edulon A (**114**) which may be regarded as a 4,5-seco-abietane derivative was isolated.⁴²⁾



The carbon-13 NMR spectra of abiatic acid and its methyl ester were published.⁴³⁾ Kinetics⁴⁴⁾ of nucleophilic substitution of chlorine in 3-chloro-2-hydroxypropyl dehydroabietate (**115**) by secondary amines and photolysis⁴⁵⁾ of N-acylimidazoles (**116** and **117**) were investigated. The irradiation of **116** yielded compounds **118** and **119**.

Syntheses of taxodione (**121**), royleanone (**122**), and their analogs (**123** and **124**) from the 12-hydroxy ester **120** were accomplished.⁴⁶⁾ Epoxidation studies with compound **125** and synthesis of **126** with C-ring functionality and stereochemistry corresponding to triptonide (**127**) were reported.⁴⁷⁾



Epoxides **129** related to triptolide (**130**) was prepared from levopimaric acid (**128**) according to the sequence shown in Chart 1.⁴⁸⁾

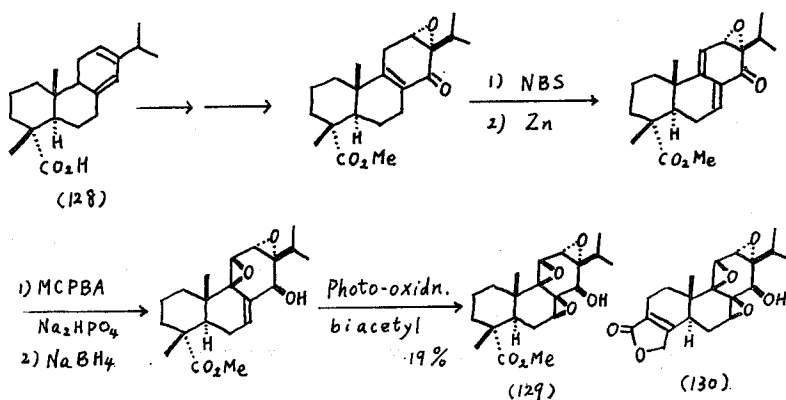
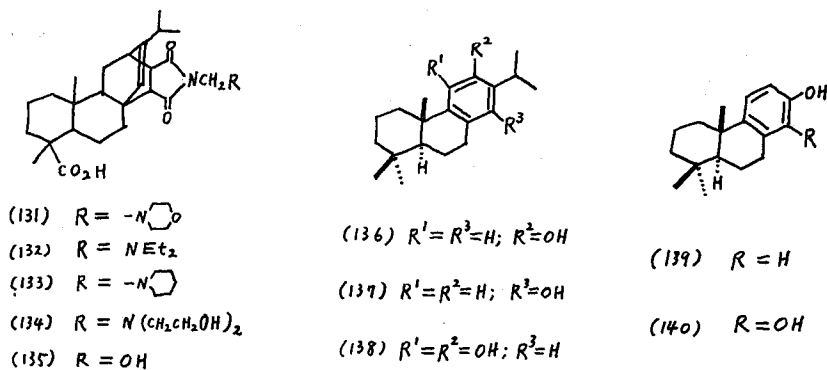
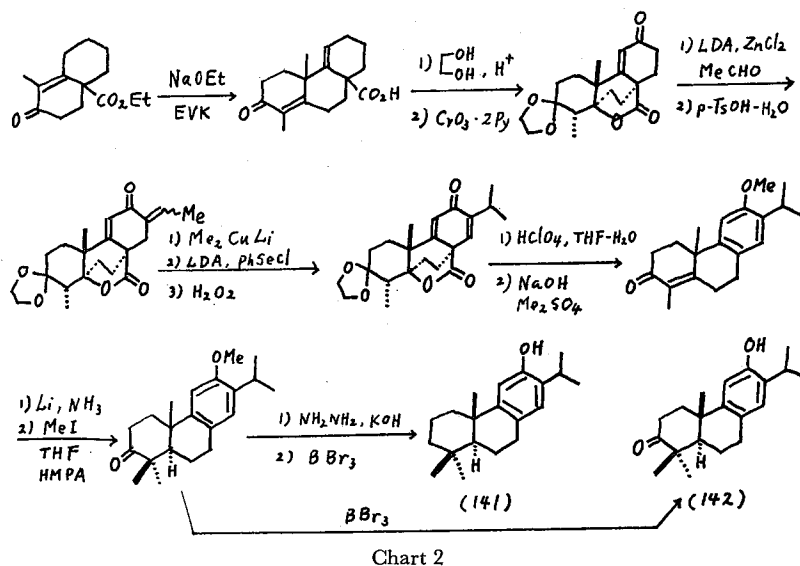


Chart 1

The N-(alkylaminomethyl)imides of maleopimaric acid, **131–134**, isolated as their amine salts, were prepared in 79~90% yields by treatment of **135** with the corresponding amine.⁴⁹⁾ Ozonolysis of phenolic dehydroabietic acid derivatives **136–140** was investigated.⁵⁰⁾

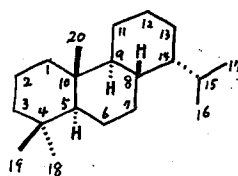


Total syntheses of (±)-ferruginol (**141**) and (±)-hinokinone (**142**) were achieved, in which the tricyclic ring system was assembled in the order of C→BC→ABC. The outline is shown in Chart 2.⁵¹⁾



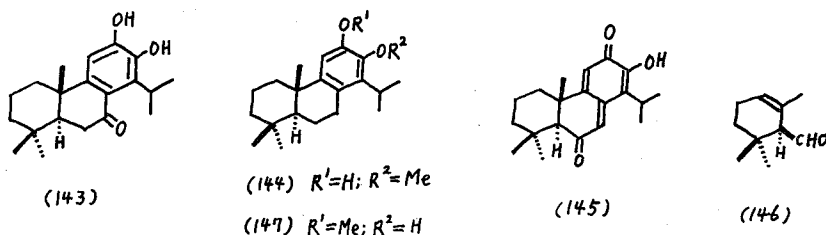
In a review on chemical constituents of the Celastraceae family isolated up to 1 March 1978, some abietane type diterpenoids were discussed.⁵²⁾

VII. TOTARANE DERIVATIVES



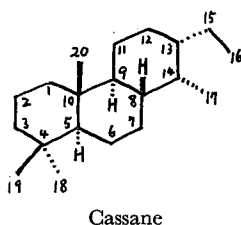
Totarane

The total syntheses of natural tricyclic diterpenes, (–)-dispermone (143), (+)-dispermol (144), and (+)-maytenoquinone (145), were achieved starting from (R)-(–)- α -cyclocitral (146) and the proposed structure 147 for dispermol was revised to 12-hydroxy-13-methoxytota-8,11,13-triene (144).⁵³⁾



In the foregoing review,⁵²⁾ maytenoquinone, dispermol, and dispermone were described.

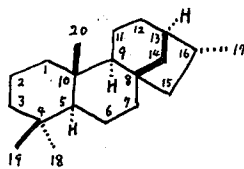
VIII. CASSANE DERIVATIVES



Cassane

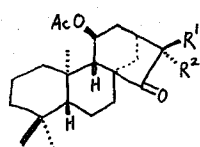
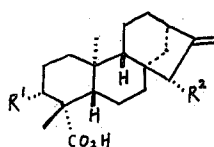
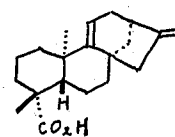
No papers have been published on the title topics in this period.

IX. KAURANE DERIVATIVES



Kaurane

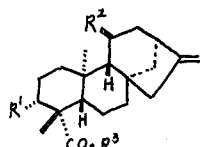
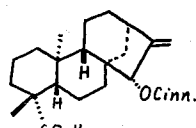
Two new diterpene acetates were isolated from *Jungermannia infusca*. Their respective structures were determined to be *ent*-15-oxokauran-11 α -yl acetate (148) and *ent*-15-oxokaur-16-en-11 α -yl acetate (149) based on the chemical and spectral evidence.⁵⁴⁾ Isolations of new diterpenes, 150 from *Bedfordia salicina*,⁵⁵⁾ and 151 and 152 from *Lagases rigida*⁵⁶⁾ were published.

(148) $R^1 = \text{Me}; R^2 = \text{H}$ (149) $R^1, R^2 = \text{CH}_3$ (150) $R^1 = \text{OH}; R^2 = \text{H}$ (151) $R^1 = \text{H}; R^2 = \text{OTiCl}_4$ 

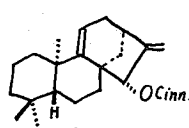
(152)

Three new diterpenes have been isolated from South African *Helichrysum* species.⁶⁾ Thus, compounds **153** and **154** from *H. cooperi*, compounds **152**, **153**, and **154** from *H. aureum* var. *monocephalum* have been isolated together with known diterpenoids kaurenoic acid and compound **155**.

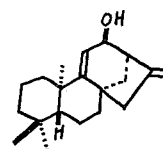
From *Montanoa pteropoda*, three new diterpenes (**156–158**) have been isolated together with a number of known kaurene type diterpenoids.⁵⁷⁾

(153) $R^1 = \text{OAc}; R^2 = R^3 = \text{H}$ (154) $R^1 = R^3 = \text{H}; R^2 = \text{OAc}$ (155) $R^1 = \text{OH}; R^2 = \text{H}; R^3 = \text{Me}$ 

(156)

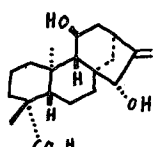


(157)

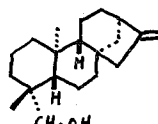


(158)

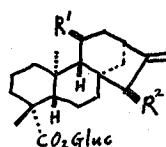
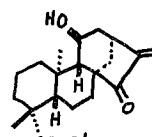
Isolations of the known kaurene type diterpenes (**159** from *Sciadocephala schultzei* and kaurenoic acid and alcohol **160** from *Critonia daleoides*) were reported.⁷⁾ From *Stevia ovata*, there were isolated five known kaurene type ester-glucosides, paniculoides-I (**161**), -II (**162**), -III (**163**), -IV (**164**), and V (**165**).⁵⁸⁾



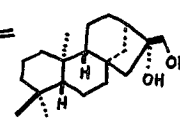
(159)



(160)

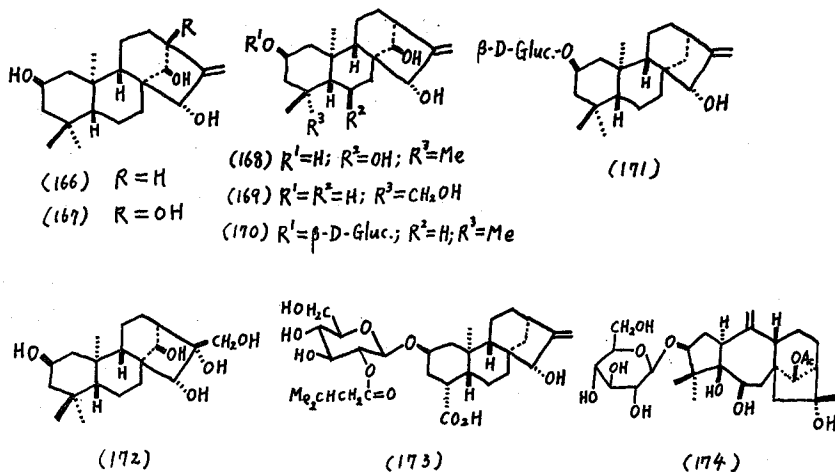
(161) $R^1 = \text{H}; R^2 = \text{OH}$ (162) $R^1 = R^2 = \text{OH}$ (165) $R^1 = \text{H}; R^2 = \text{OGlc}$ 

(163)

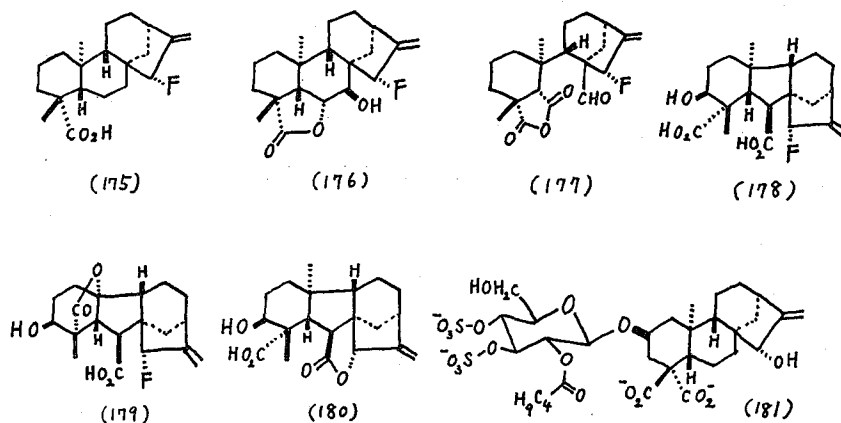


(164)

From *Pteris plumbaea*, five new diterpenes (**166–170**) were isolated together with the known *ent*-kaurene-derivatives **171** and **172**.⁵⁹⁾ A new atractyligenin glucoside was isolated from green coffee-beans. Its structure was determined by spectral data and chemical reactions to be **173**.⁶⁰⁾ A new diterpene glucoside, grayanoside A (**174**) was isolated from *Leucothoe grayana*.⁶¹⁾

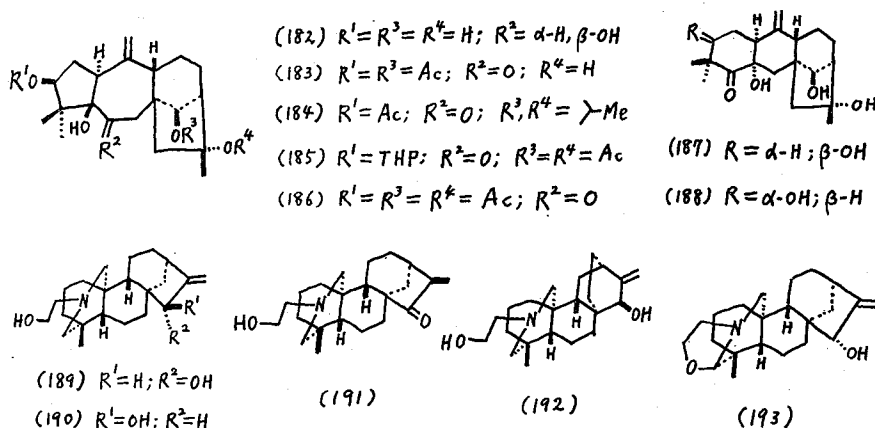


Carbon-13 NMR spectroscopy of atisine and veatchine-type C_{20} -diterpenoid alkaloids from *Aconitum* and *Garrya* species was reported. In this paper, it was indicated that the C-20 epimers of atisin did not exist in an equilibrium mixture in solution and were not interconvertible *via* a zwitterion as reported earlier.⁶²⁾ 15 α -Fluorokaurenoic acid (175) was prepared and fed to fermentations of *Gibberella fujikuroi*; the products have been shown to include 15 α -fluoro-7 β -hydroxykaurenolide (176), 15 α -fluorofujenal (177), and gibberellin derivatives (178–180).⁶³⁾ In a review on “transport catalyst in biomembrane illustrated by example of ADP, ATP-carriers of mitochondria”, carboxyatractylate 181 was cited.⁶⁴⁾



Acyloin rearrangement of 6-dehydro derivatives of grayanotoxin-II (182) was investigated and compounds (183–186) were converted to a 6/6 membered ring system (187 and 188) in alkaline media.⁶⁵⁾

A simple method using active MnO_2 for converting the -N-CH₂-CH₂-OH group-containing alkaloid derivatives (189–192) into their iso-oxazolidine ring-containing alkaloids (e.g. garryine 193) was reported.⁶⁶⁾



A simple and efficient method for converting the oxazolidine-ring containing alkaloids, *e.g.*, ovatine (194), garryfoline (195), and veatchine (196), into their corresponding imine derivatives was published.⁶⁷⁾ (See Chart 3.)

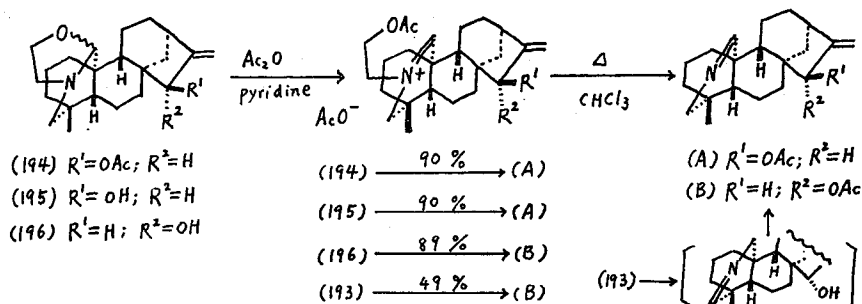
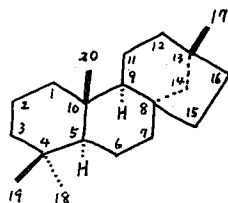


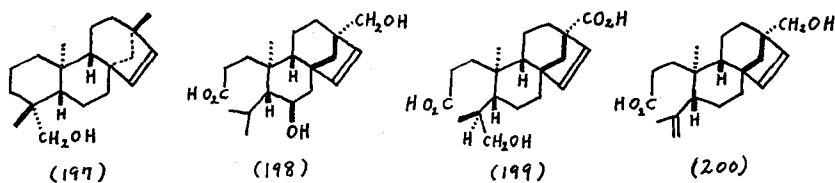
Chart 3

X. BEYERANE DERIVATIVES

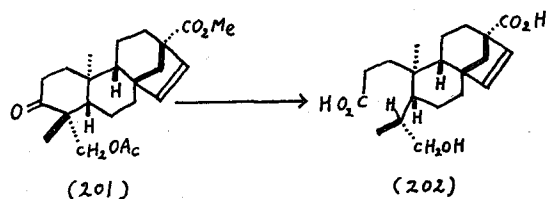


Beyerane

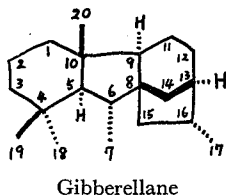
From *Montanoa pteropoda*, the known beyerane-type diterpene 197 was isolated together with kaurene-type diterpenes.⁵⁷⁾ Isolation of two new secobeyerene diterpenes (198 and 199) from *Beyeria calycina* was reported.⁶⁸⁾ This paper describes also a feeding experiment indicating quite distinct pathway to the seco acid 200 and the 6-hydroxydihydro analog 198.



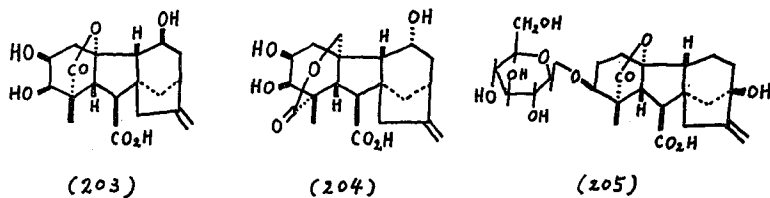
The photolysis of 3-oxo-beyerene derivative **201** occurred with retention of configuration of C-4 to give the 4S-3,4-seco acid **202**. In this phototransformation, the C-2 axial hydrogen is transferred preferentially to C-4.⁶⁹⁾



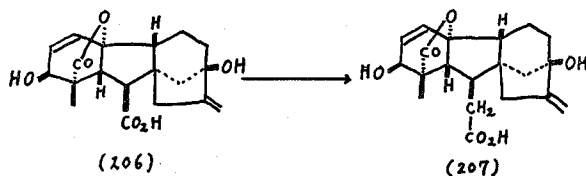
XI. GIBBERELLANE DERIVATIVES



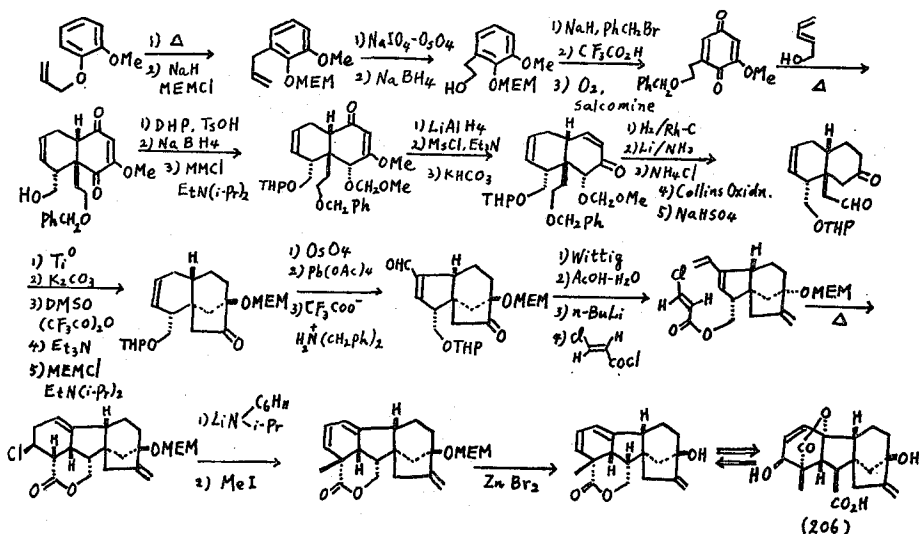
Two new gibberellins A₅₀ (**203**) and A₅₂ (**204**) were isolated from seeds of *Lagenaria leucantha* var. *clavata*.⁷⁰⁾ A novel gibberellin glucoside was isolated from immature seed of *Dolichos lablab* and its structure was determined to be 3-O-β-D-glucopyranosyl gibberellin A₁ (**205**).⁷¹⁾



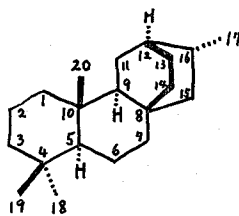
The inhibitory effects of 1-alkylimidazoles on the gibberellin biosynthesis of *Gibberella fujikuroi* were reported.⁷²⁾ Microbiological production of fluorogibberellins (**178–180**) was reported.⁶³⁾ 7-Homogibberellin A₃ (**207**) was partially synthesized from gibberellin A₃ (**206**). Thus, the latter was treated with (COCl)₂ and CH₂N₂ to give a diazoketone, which was photochemically rearranged and then hydrolyzed with NaOMe.⁷³⁾



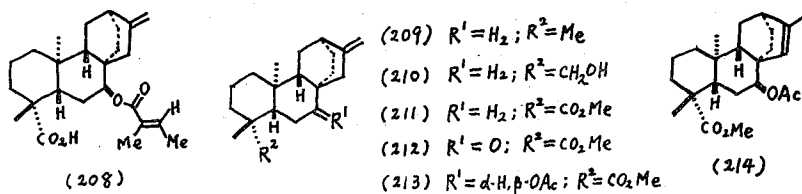
Stereospecific total synthesis of gibberellic acid (206) was achieved by Harvard team.^{74,75)} The synthetic pathway is shown in Chart 4.



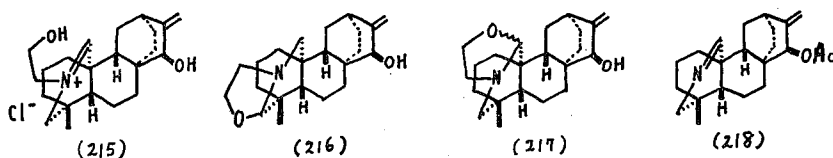
XII. ATISANE DERIVATIVES



From the roots of *Margotia gummifera*, a new diterpenoid, gummiferolic acid (208) was isolated in very high yield (2% of the dry plant), together with the known *ent*-kaur-16-en-19-oic acid.⁷⁶⁾ A satisfactory method for quantitative determination of a series of diterpene alkaloids in Japanese aconite roots was developed, using the combination of dual wave length thin-layer chromatography scan and gas chromatography.⁷⁷⁾ Carbon-13 NMR spectra of some *ent*-atisene derivatives (209–214) were reported.⁷⁸⁾



Carbon-13 NMR spectroscopy of atisine-type alkaloids from *Aconitum* species⁶²⁾ and X-ray crystallography of four C₂₀-diterpenoid alkaloids (192, 196, 215, and 216)⁷⁹⁾ were investigated. In these papers, epimerization and isomerization in their alkaloids were discussed. A simple and efficient method for the degradation of the oxazolidine ring of C₂₀-diterpene alkaloids [216, 217→218] was published,⁶⁷⁾ as mentioned above.



Dihydroatisine (192) was converted to isoatisine (216) using active MnO₂.⁶⁶⁾ An aconite alkaloid, kobusine (219) was converted to a C₁₄-C₂₀ bond cleaved derivative 221 by a novel fragmentation reaction *via* a chloramine 220. Furthermore, the C₁₄-C₂₀ bond regeneration in compound 221 was also accomplished by intramolecular Grignard type reaction.⁸⁰⁾ (See Cahrt 5.)

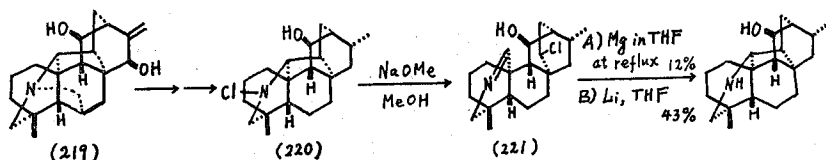
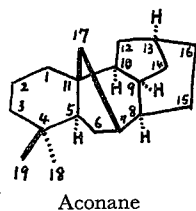


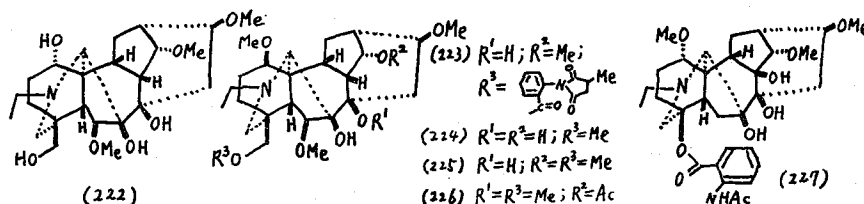
Chart 5

XIII. ACONANE DERIVATIVES

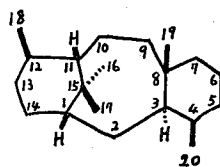


A method for the quantitative analysis of a series of diterpene alkaloids in Japanese aconite roots was developed.⁷⁷⁾ The structure of gigactonine (222) isolated as a new base from *Aconitum giga* was determined.⁸¹⁾ The diterpene alkaloids of *Delphinium brownii* were re-examined. As the result, it was found that, in addition to 223 and 224,

browniine 14-O-acetate (225) occurs in the bases extracted from aerial portions of the plant.⁸²⁾ Ambiguine (226) and dihydroajaconine, two new minor diterpene alkaloids obtained from *Consolida ambigua* were characterized by ¹³C NMR.⁸³⁾ The structure of ranaconitine, a new alkaloid of *Aconitum ranunculaefolium*, was reported as 227.⁸⁴⁾



XIV. TAXANE DERIVATIVES

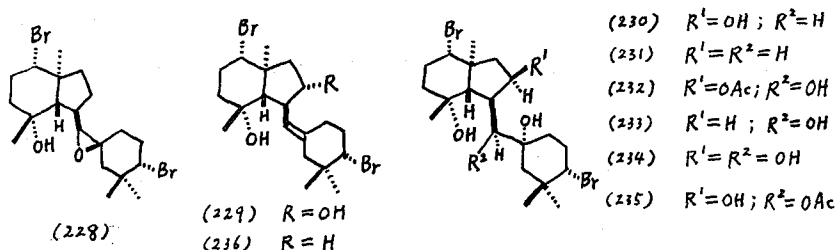


Taxane

No reports have been reported on the title topics in this period.

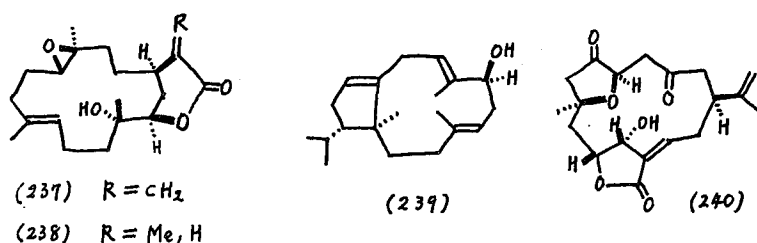
XV. THE OTHERS

The structures of the previously reported irienol A (228) and iriediol (229) were further refined as shown. The structures of irieol B (230), C (231), D (232), E (233), F (234), G (235), and irieol (236) were reported.⁸⁵⁾ They are new dibromo-diterpenoids of a unique skeletal class from the red seaweed *Laurencia iriei*.

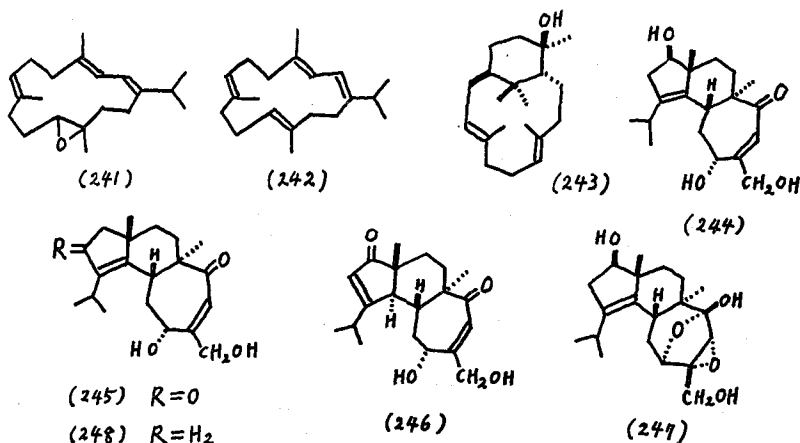


Two new cembranoid lactones, flexibilide (237) and dihydroflexibilide (238), were isolated from an Australian collection of the soft coral *Sinularia flexibilis*. The structure and relative configuration of flexibilide (237) was determined by single-crystal X-ray diffraction method.⁸⁶⁾ The structure of a novel bicyclic diterpene alcohol obtained from an unknown species of soft coral was reported and shown to be 239 by the chemical and crystallographic study.⁸⁷⁾ The structure of a novel nor-cembranoid

diterpene isolated from the soft coral *Sinularia leptoclados* was determined as **240** by X-ray analysis.⁸⁸⁾

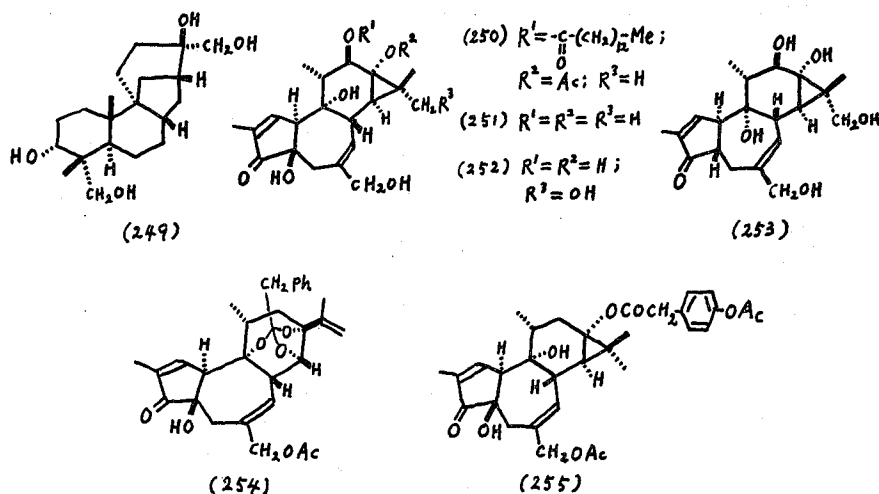


The isolations of epoxyisoneocembrene-A (**241**) from the soft coral *Sinularia grayi* and of isoneocembrene-A (**242**) from the soft coral *Sarcophyton ehrenbergi* were reported. Their structures were demonstrated by chemical and spectroscopic means.⁸⁹⁾

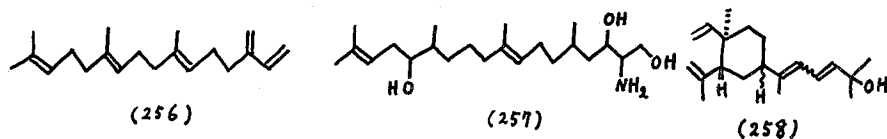


The structure and absolute configuration of verticillol (**243**), a macrocyclic diterpene alcohol from the wood of *Sciadopitys verticillata*, were assigned on the basis of physicochemical studies.⁹⁰⁾ Four new diterpenes which were named cyathrin A₄ (**244**), cyathrin B₄ (**245**), allocyathrin B₄ (**246**), and cyathrin A₅ (**247**) were isolated together with the known compounds from the liquid culture of the bird's nest fungus *Cyathus africanus* Brodie.⁹¹⁾ The Carbon-13 NMR spectra of cyathin A₃ (**248**) and several related compounds were measured and the chemical shifts were assigned.⁹²⁾

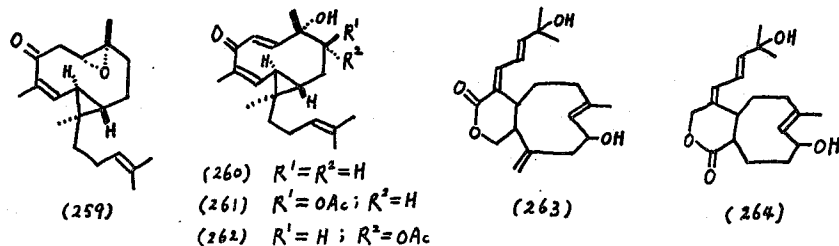
The isolation and identification of aphidicolin (**249**) contained in the culture filtrate of the fungus *Harziella entomophilla* as well as the biological activity of this compound as a root growth inhibitor were reported.⁹³⁾ This compound prevented mitotic cell division by interfering with the activity of DNA polymerase- α .⁹⁴⁾ Phorbol derivative **250** was described in the research news about tumor promoters.⁹⁵⁾ In a review on cocarcinogen, several highly irritant diterpenes, phorbol (**251**), 16-hydroxyphorbol (**252**), 4-deoxy-16-hydroxyphorbol (**253**), and their esters were discussed in detail.⁹⁶⁾



Two minor diterpenes, 254 and 255, were isolated from *Euphorbia latex*.⁹⁷⁾ Three new diterpenes, coleonol-B, -C, and deoxycoleonol were isolated from *Coleus forskohlii*.⁹⁸⁾ A new diterpene analog, β -springene (256), was isolated from the dorsal gland of the springbok *Antidorcas marsupialis*.⁹⁹⁾ Aplidiasphingosine (257), an antimicrobial and antitumor terpenoid, was isolated from an *Aplidium* species.¹⁰⁰⁾ Fuscol (258), a new elemene-type diterpene alcohol, was isolated from the gorgonian *Eunicea fusca*.¹⁰¹⁾

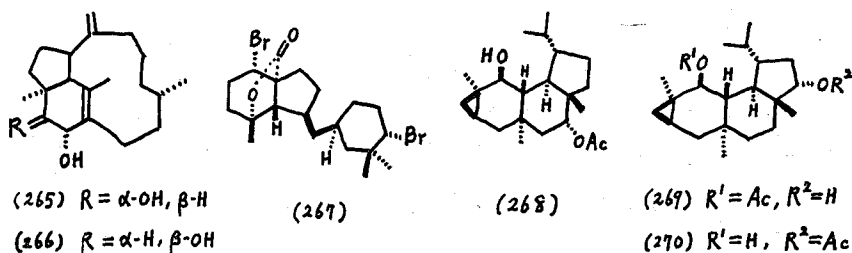


The isolation of four new diterpenes, epoxydilophone (259), dilopholone (260), epiacetoxylidopholone (261), and acetoxylidopholone (262), from the brown alga *Dilophus prolifcans* was reported.¹⁰²⁾ Two new diterpenes, xeniolide-A (263) and -B (264), were isolated from the soft coral *Xenia macrospiculata*.¹⁰³⁾

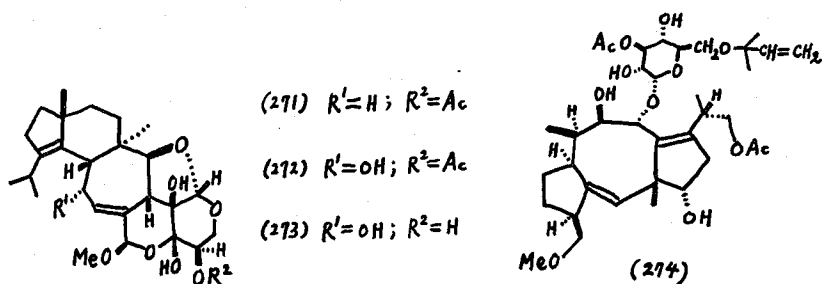


The structures 265 and 266 were assigned to the compounds isolated from the frontal glands of *Nasutitermes costalis* soldiers.¹⁰⁴⁾ The structure and absolute configuration of a new dibromo-diterpene, angasiol, isolated from the South Pacific Ocean sea hare *Aplysia angasi* was determined as 267 by X-ray analysis.¹⁰⁵⁾ Three new mono-

acetates of diterpene diols were isolated from *Mylia verrucosa* and the structures were determined as 268, 269, and 270 on the basis of chemical and spectral evidence.¹⁰⁶⁾



Striatins A, B, and C, novel diterpenoid antibiotics, were isolated from *Cyanthus striatus*. Striatin A (271) was shown by X-ray analysis to contain a cyathin skeleton triple linked to a pentose unit. This result allowed the assignment of structures to the closely related striatins B (272) and C (273).¹⁰⁷⁾ Mechanism of geranylgeranyl pyrophosphate cyclization in fusicoccin (274) biosynthesis was discussed by use of deuterium as a tracer with ^{13}C NMR spectroscopy.¹⁰⁸⁾



(\pm)-Ligantrol (276), isolated from *Liatris elegans*, was synthesized from the hypothetical precursor, 18-hydroxygeranylnerol (275) which was an isomer of 18-hydroxygeranylgeraniol isolated from *Croton sublyratus* as an antigastric ulcer principle.¹⁰⁹⁾ The synthetic route is shown in Chart 6.

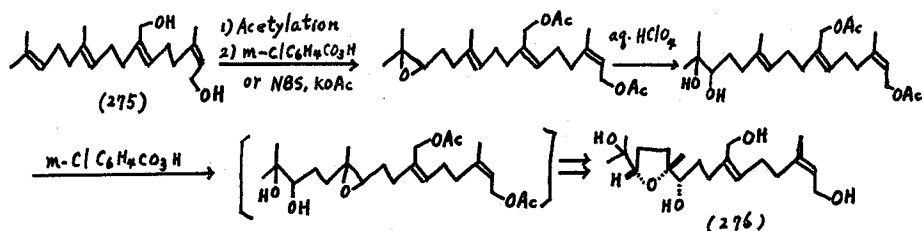
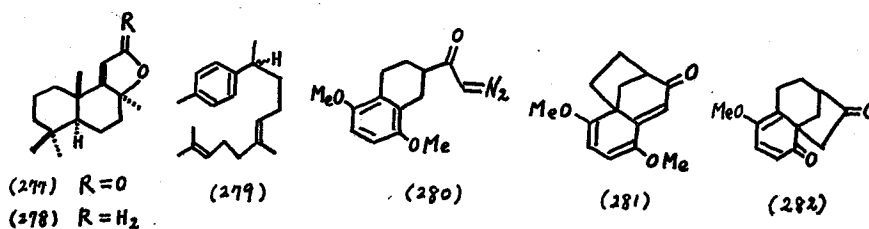


Chart 6

A synthesis of (\pm)-norisoambreinolide (277) and (\pm)-isoambrox (278) was reported.¹¹⁰⁾ Syntheses of (\pm)-2,6-dimethyl-10-(*p*-tolyl)undeca-2,6-(*E*)-diene (279), the diterpene of *Salvia dorisiana* were reported.^{111,112)} The acid-catalyzed cyclization

of diazomethyl 5,8-dimethoxy-1,2,3,4-tetrahydro-2-naphthyl ketone (280) into compound 281 or 282 was reported.¹¹³⁾



A rearrangement of bicyclo [2.2.2] octene precursors 283 and 284 into bridgehead-substituted bicyclo [3.2.1] octene derivatives 285 and 286 was investigated, which may be available for construction of the C-D ring system of gibberellic acids, beyerenes, and grayanotoxins.¹¹⁴⁾ The mechanistic route is shown in Chart 7.

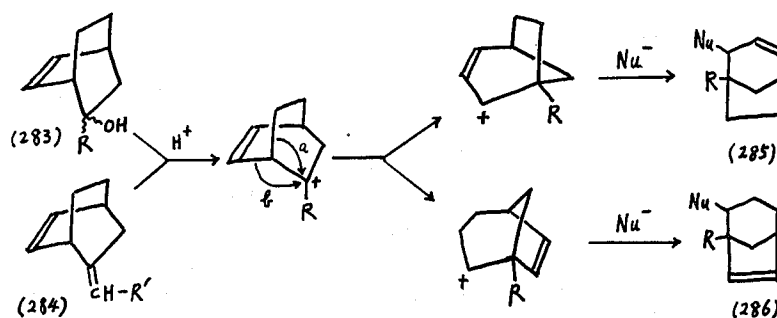
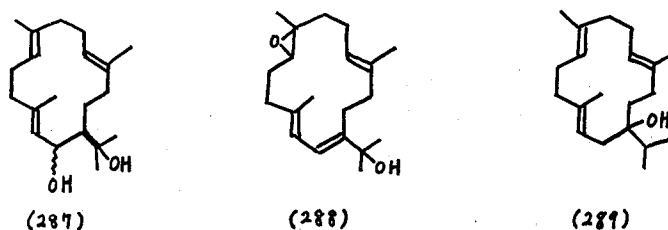


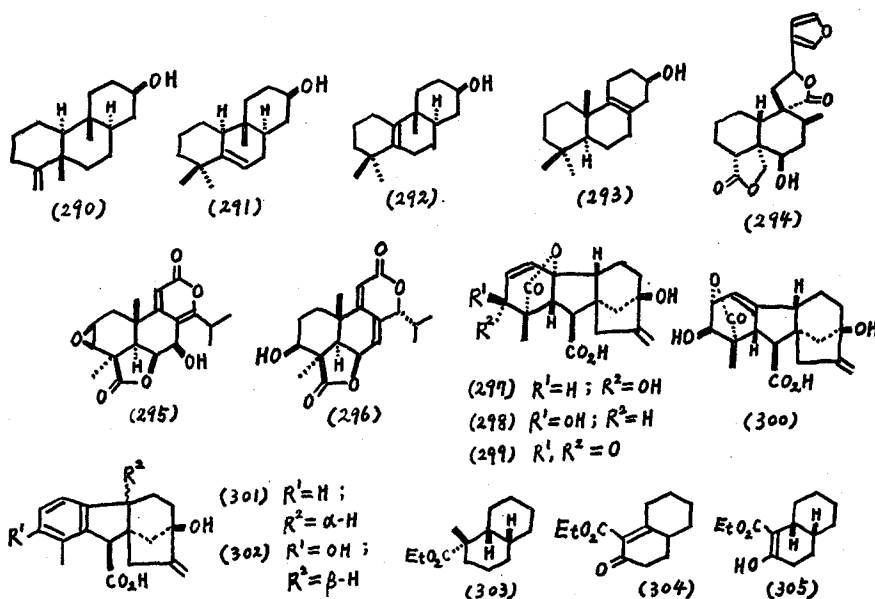
Chart 7

The naturally occurring cembrenoids, 287, 288, and 289 were successfully synthesized, demonstrating unequivocally the assigned structure.¹¹⁵⁾



ADDENDA

Refluxing the compound 290 having the skeleton of dolabradiene with formic acid for 30 hours followed by chromatography gave 291–293 in 60, 10, and 11.4% yields, respectively.¹¹⁶⁾



The structure of teucrin H₂ (294), isolated from *Teucrium hyrcanicum*, was confirmed by NMR, IR, UV, and mass spectroscopy and by reduction, hydrogenation, and oxidation products.¹¹⁷⁾ Two new diterpenoid dilactones related to nagilactone A, isolated from *Podocarpus nagi*, were shown to have structures 295 and 296 according to their NMR spectra and chemical correlations.¹¹⁸⁾ The mass spectra of gibberellins 297–302 were reported. All the compounds showed the same skeletal fragmentation.¹¹⁹⁾ Diterpene synthon 303 was prepared by cyclocondensation of cyclohexanone pyrrolidine enamine with $CH_2=CHCOCH_2CO_2Et$, hydrogenation of the octahydronaphthalenone 304, and methylation of the naphthalenol 305 with methyl iodide. Compound 305 was reduced to the corresponding alcohol, the structure of which was determined by X-ray crystal structure analysis.¹²⁰⁾ A new diterpene, coleosol, was isolated from *Coleus forskohlii*.¹²¹⁾

Cyafrin A₄ (244), cyafrin B₄ (245), allocyafrin B₄ (246), and cyafrin A₅ (247) isolated from *Cyathus africanus*, a bird's nest fungus, were described again, and metabolites of other bird's nest fungi were reviewed.¹²²⁾ Mass spectral fragmentation patterns were determined for teucrin H₁–H₄ (58–61) isolated from *Teucrium hyrcanicum*.¹²³⁾

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